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**SPECIFICATION FOR
EAR PROTECTORS**

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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Price Group 4

Indian Standard

SPECIFICATION FOR EAR PROTECTORS

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Indian Standard

SPECIFICATION FOR EAR PROTECTORS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 20 March 1979, after the draft finalized by the Acoustics Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 While preparing this standard assistance has been derived from the following:

CSA Standard Z 94.2-1965 Hearing protectors. Canadian Standards Association.

JIS B 9904-1955 Noise-proof type ear plug. Japanese Standards Association.

ANSI S 3.19-1974 Methods for the measurement of real ear protection of hearing protectors and physical attenuation of earmuffs. American National Standards Institute.

0.3 Noise, unwanted sound, is present in all environments, predominantly in industrial environments. Exposure to high-intensity noise may cause hearing impairment. The degree of such impairment depends on the noise level and duration as well as the sensitivity of the individual.

0.3.1 However, the use of adequate hearing conservation procedure which include the use of proper ear protectors, can prevent or reduce most cases of such hearing impairment.

0.3.2 For institution of hearing conservation programmes, there is need for assessment of noise exposure and IS : 7194-1973* has been prepared to determine the effect of occupational noise exposure and its duration on hearing impairment.

0.4 This edition 1.1 incorporates Amendment No. 1 (October 1993). Side bar indicates modification of the text as the result of incorporation of the amendment.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

*Assessment of noise exposure during work for hearing conservation purposes.

†Rules for rounding off numerical values (*revised*).

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1. SCOPE

1.1 This standard covers the performance requirements for devices for personal hearing protection.

2. TERMINOLOGY

2.1 For the purpose of this standard, the terms and definitions contained in IS : 1885 (Part III)* and IS : 6229-1971†, in addition to the following, shall apply.

2.1.1 *Headband* — A device, other than a helmet, that holds the ear protector in proper position.

2.1.2 *Type Tests* — Tests carried out to prove conformity with the requirement of the relevant specification. These are intended to check the general qualities and design of a given type.

2.1.3 *Acceptance Tests* — Tests carried out on samples selected from a lot for the purpose of acceptance of the lot.

2.1.3.1 *Lot* — All ear protectors of the same type, category and rating manufactured by the same factory during the same period using the same materials and processes.

3. CLASSIFICATION

3.1 The ear protectors covered in this standard are classified as follows:

- a) Ear-plugs — permanent or disposable,
- b) Ear-muffs, and
- c) Helmets.

NOTE — The ear protectors may also be classified according to the noise reduction performances, for example:

- a) Those which reduce all sounds inclusively from high to low tones, and
- b) Ear protectors which reduce sounds of high tones only.

4. MATERIALS

4.1 All materials coming into contact with the body shall not be of a type known to cause irritation, and shall be resistant to skin oil, hair oil, and ear wax. The material shall be moisture-proof, heat resistant and cold-proof.

4.2 The materials to be used shall not be damaged readily under normal handling, and its strength, hardness and elasticity shall be suitable for the purpose it is to serve.

*Electrotechnical vocabulary: Part III Acoustics.

†Method of measurement of the real-ear attenuation of ear protectors at threshold.

4.3 Ear protectors, permanent type, shall be made of materials that are capable of being cleaned and sterilized.

5. CONSTRUCTION AND WORKMANSHIP

5.1 The ear protectors should be so constructed that no deleterious changes occur between $- 25^{\circ}\text{C}$ and $+ 55^{\circ}\text{C}$.

5.2 Ear-plugs should be elastic to the ear canal, and shall be designed so as not to give uncomfortable feeling to the wearer and not to fall off easily from the ear when being worn.

5.3 The ear-muff, type of ear protectors shall be so constructed as to facilitate fastening of pair of them, for example, by means of headband.

6. TESTS AND REQUIREMENTS

6.0 Classification of Tests

6.0.1 *Type Tests* — All tests specified in this standard shall constitute type test and shall be carried out on 10 samples. There shall be no single failure. The tests shall be performed in the order given.

6.0.2 *Acceptance Tests* — The following shall constitute acceptance tests and shall be performed in the order given:

- a) Visual examination (*see* **6.1.1**)
- b) Damp heat (accelerated) (*see* **6.1.2**)
- c) Rapid change of temperature (*see* **6.1.3**)
- d) Low temperature impact (*see* **6.1.5**)
- e) Cleanability (*see* **6.1.6**)
- f) Headband extension (*see* **6.1.8**)
- g) Sound attenuation (*see* **6.2**)

6.0.2.1 The number of samples and acceptance criteria is given in Appendix A.

6.1 Physical Requirements

6.1.0 *General* — A list of tests for physical requirements is given in Table 1 indicating their applicability to ear-plug and ear-muff.

6.1.1 *Visual Examination* — The ear protector shall be examined to check comparatively compliance with manufacturer's literature, drawings and/or marking normally supplied to the user.

TABLE 1 TESTS FOR PHYSICAL REQUIREMENTS

(Clause 6.1.0)

TESTS	EAR-PLUG		APPLICABILITY EAR-MUFFS	HELMET	TEST CLAUSE
	Perma- nent	Dispos- able			
(1)	(2)	(3)	(4)	(5)	(6)
Visual examination	√	√	√	√	6.1.1
Rapid change of temperature	√	√	√	√	6.1.3
Low air pressure	√	×	√	√	6.1.4
Low temperature impact	×	×	√	√	6.1.5
Cleanability	√	×	√	√	6.1.6
Headband extension	×	×	√	×	6.1.8

NOTE — Tick (√) mark indicates applicability and cross mark (×) indicates non-applicability.

6.1.2 Damp Heat Test, Accelerated — This test shall be carried out in accordance with IS : 9000 (Part 5/Sec 1)-1987 for one cycle. The ear protectors shall be examined for:

- a) visual examination, and
- b) sound attenuation requirements.

6.1.3 Rapid Change of Temperature Test — The ear protector shall be subjected to rapid change of temperature in accordance with IS : 9000 (Part 14/Sec 2)-1978, the upper and lower temperature severities being + 55°C and – 25°C. The ear protectors shall be examined at the end of the five cycles. This shall not:

- a) show either excessive adhesiveness or excessive change in hardness, and
- b) shall not crack or rupture or deteriorate permanently.

6.1.4 Low Air Pressure Test — During the last cycle of rapid change of temperature test (*see* 6.1.2) the internal pressure of the chamber shall be reduced to 60 kPa for a period of not less than 15 minutes each at both the high and low temperature (*see* IS : 9000 (Part 13)-1981). The ear protector shall be examined for any crack or rupture or permanent deterioration.

6.1.5 Low Temperature Impact Test — The ear protector shall be placed in an environmental chamber and the air temperature in the chamber shall be reduced to -25°C . Immediately after 3 hours of conditioning at the specified low temperature, the ear protector shall be dropped 3 times in quick succession from a height of 1.0 metre on to a smooth, horizontal concrete surface. The ear protector shall be examined for any crack or rupture or permanent deterioration.

6.1.6 Cleanability Test — The ear protector shall be lightly soiled on its external surfaces by manipulation of hands oiled with liquid petrolatum (mineral oil, liquid paraffin) and graphite mixtures. The ear protector shall then be cleansed thoroughly and disinfected according to the manufacturer's instructions. This will constitute one soiling and cleaning cycle. Ten such cycles shall be performed. The ear protectors shall not show any permanent damage due to soiling and shall show clean surfaces. After soiling ear protectors shall be exposed to one cycle of rapid change of temperature test (*see* 6.1.3) before cleaning. The ear protectors shall be examined for decolouration.

6.1.7 Salt Mist Test — This test shall be carried out in accordance with IS : 9000 (Part 11)-1983, the duration of conditioning being one day.

6.1.8 Headband Extension Test — Spring headbands with adjustment provisions shall be adjusted half-way between maximum and minimum extension. The ear protectors shall then be forced apart until the separation between the two surfaces that are normally in contact with the ear-head is approximately 20 cm. This shall constitute one cycle. Twenty-five such cycles shall be carried out. At the completion of these cycles the separation shall be increased to $15.0 + 5$ cm by means of a force applied midway between the top and bottom level of the cup and this force shall not be less than 7N or greater than 12N. Spring headbands without adjustment provisions shall be tested in the same manner as those with adjustment provisions.

6.2 Sound Attenuation Measurement

6.2.1 The measurement of the sound attenuation of a ear protector shall be carried out in accordance with IS : 6229-1971* or by the 'physical method' given in Appendix B or both and shall meet the requirements specified in Table 2. The objective method of measurement of sound attenuation is for comparison purposes only.

*Method of measurement of the real-ear attenuation of ear protectors at threshold.

TABLE 2 SOUND ATTENUATION REQUIREMENTS

(Clause 6.2.1)

GROUP	TEST FREQUENCY	GROUP SOUND ATTENUATION, <i>Min</i>	
		Muffs	Plugs
(1)	(2)	(3)	(4)
	Hz	dB	dB
A	125	25	25
	250		
B	500	175	135
	1 000		
	2 000		
	3 000		
C	4 000	60	60
	6 000		
	8 000		

NOTE 1 — The minimum group attenuation is the sum of mean attenuation for each of the test frequencies contained in that group.

NOTE 2 — The acceptable minimum sound attenuation for each of the single test frequencies contained in Group B shall be as follows:

Test Frequency Hz	Sound Attenuation, <i>Min</i>	
	Muffs	Plugs
500	25	20
1 000, 2 000	35	25
3 000, 4 000		

7. MARKING

7.1 The following information regarding the construction, performance and use of ear protectors shall be provided by the manufacturer to the user:

- a) Sound attenuation in decibels at 125, 250, 500, 1 000, 2 000, 3 000, 4 000, 6 000 and 8 000 Hz;
- b) Test tension of headband if applicable;
- c) Overall mass;
- d) Temperature range;

- e) Lower pressure severity;
- f) Instructions for cleaning, and
- g) Instructions for use.

7.2 Each ear protector should preferably be marked with the name of trade-mark or designation of the manufacturer.

8. MAINTENANCE

8.1 Component parts subject to breakage or deterioration shall be replaceable.

8.2 Manufacturer's instructions shall include details of any maintenance requirements and a list of the replacement spare parts which are necessary shall be provided with the ear protector.

APPENDIX A

(Clause 6.0.2.1)

A-1. SCALE OF SAMPLING

A-1.1 The conformity of the lots to the requirements of this specification shall be ascertained for each lot separately. The number of ear protectors to be selected for this purpose shall depend upon the size of the lot and shall be in accordance with col 1 and 2 of Table 3.

TABLE 3 SCALE OF SAMPLING AND PERMISSIBLE NUMBER OF DEFECTIVES

(Clauses A-1.1, A-2.1, A-2.2 and A-2.3)

NUMBER OF EAR PROTECTORS IN THE LOT	VISUAL EXAMINATION, HEADBAND EXTENSION AND SOUND ATTENUATION		LOW TEMPERATURE IMPACT AND CLEANABILITY		DAMP HEAT TEST (ACCELERATED) AND RAPID CHANGE OF TEMPERATURE, SAMPLE SIZE
	Sample Size	Permissible Number of Defectives	Sample Size	Permissible Number of Defectives	
(1)	(2)	(3)	(4)	(5)	(6)
Up to 50	5	0	3	0	2
51 ,, 100	8	0	5	0	3
101 ,, 300	13	0	8	0	5
301 ,, 500	20	1	13	0	6
501 and above	32	1	20	1	7

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A-1.1.1 These ear protectors shall be selected from the lot at random. In order to ensure the randomness of selection, procedure given in IS : 4905-1968* may be followed.

A-2. NUMBER OF TESTS AND CRITERIA FOR CONFORMITY

A-2.1 The ear protectors selected according to col 1 and 2 of Table 3, shall be examined for visual requirements and subjected to tests for headband extension and sound attenuation. An ear protector failing to satisfy any of these requirements shall be considered as defective. The lot shall be considered as conforming to the requirements if the number of defective ear protectors found in the sample is less than or equal to corresponding permissible number given in col 3 of Table 3. The lot shall be rejected without any further testing if the number of defective ear protectors in the sample is greater than corresponding permissible number or defectives.

A-2.2 The lot which has passed the requirements in **2.1** shall be further tested for low temperature impact and cleanability. For this purpose, the number of ear protectors given in col 4 of Table 3 shall be taken from those examined under **A-2.1** and found satisfactory. An ear protector failing to satisfy either of the requirements shall be considered as defective. The lot shall be considered as conforming to these requirements if number of defective ear protectors found in the sample is less than or equal to corresponding permissible number given in col 5 of Table 3. The lot shall be rejected without any further testing if the number of defective ear protectors in the sample is greater than corresponding permissible number of defectives.

A-2.3 The lot which has passed the above requirements shall be further tested for damp heat test (accelerated) and rapid change of temperature. For this purpose, the number of ear protectors given in col 6 of Table 3, shall be taken from those examined under **A-2.2** and found satisfactory. The lot shall be considered as meeting the requirements of these tests if none of the ear protectors tested fails to meet either of the requirements.

A-2.4 The lot shall be considered as conforming to the requirements of this specification if **A-2.1**, **A-2.2** and **A-2.3** are satisfied.

*Methods for random sampling.

APPENDIX B

(Clause 6.2.1)

B-1. PHYSICAL METHOD

B-1.1 Physical Requirements

B-1.1.1 Test Room

B-1.1.1.1 Acoustic test field— A random incidence sound field, as approximated by the following conditions is desired for each third-octave band test frequency from 80 to 10 000 Hz:

- a) A broad-band electrical noise source, whose spectrum level in 1-Hz bands is uniform within ± 2 dB over the frequency range of 50 to 12 500 Hz, shall be presented to a third-octave contiguous filter set ranging from 80 to 10 000 Hz centre frequency to provide the test signals. Each of the test bands beginning at 125 Hz and extending to 8 000 Hz centre frequency shall be measured.
- b) The band pressure level at the microphone for each test band frequency shall be not less than 85 dB with reference to $20 \mu\text{Pa}$ and shall be at least 60 dB higher than the level of the test room ambient noise in each test frequency band.
- c) The random incidence characteristics of the sound field shall be determined as given below. The sound field used in the primary method is adequate for the physical measures when the band pressure level requirement of (b) is satisfied.

A directional (cosine or cardioid) microphone that exhibits in its freefield polar response at least 10 dB (front-to-side and front-to-back rejection for each test band shall be used to measure the sound field at the test space. The sound field shall be considered to approximate a random incidence field if, when the microphone is rotated about the centre of the test space through 360° in each of the three perpendicular planes of the room, the observed sound pressure level in each test band remains within the variation allowed in Table 4.

B-1.1.2 Apparatus

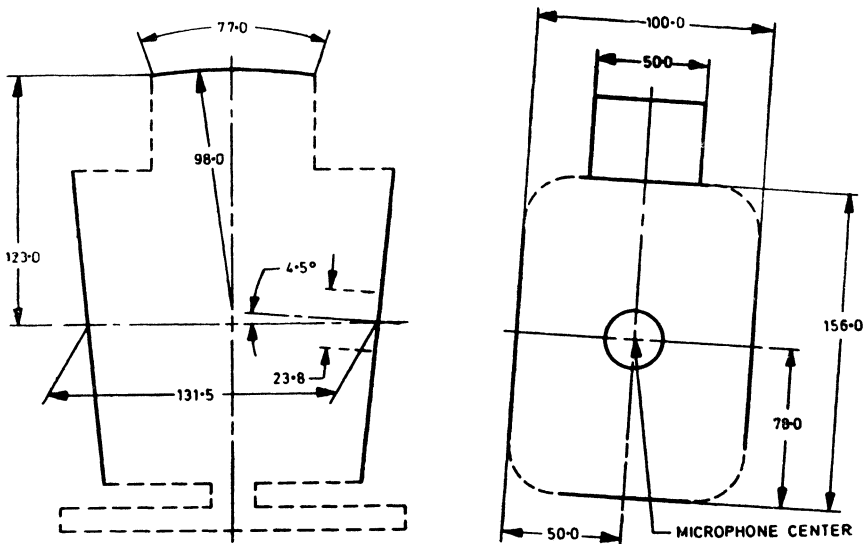
B-1.1.2.1 Dummy head— The dummy head shall be constructed in accordance with the critical surface dimensions as shown in Fig. 1. The two nonparallel surfaces, representing the sides of the human head, and the curved surface representing the top of the human head. There shall also be provided in one or both surfaces, as shown in Fig. 1, a centrally located mounting means that shall accept a suitable measuring microphone. Adapters shall be used with microphone having outside diameters less than $23.744 \text{ mm} \pm 0.005 \text{ mm}$.

TABLE 4 ALLOWABLE RANDOM INCIDENCE FIELD RESPONSE VARIATION FOR CORRESPONDING MICROPHONE FREE-FIELD REJECTION*

(Clause B-1.1.1.1)

MICROPHONE FREE-FIELD REJECTION (dB)	ALLOWABLE RANDOM INCIDENCE FIELD RESPONSE VARIATION
(1)	(2)
> 25	6
20	5
15	4
10	3
< 10, microphone not suitable	—

*The variation in microphone response as the microphone is rotated in a random incidence field is related to the directional characteristics of the microphone and the degree of randomness of the field. Allowable sound field response variations shall be presented in terms of the free-field directional response characteristic of the microphone. This table presents the free-field rejection values of directional microphones and corresponding allowable sound field variations for purposes of this standard. The microphone free-field rejection may be obtained by measurement or from the microphone manufacturer.



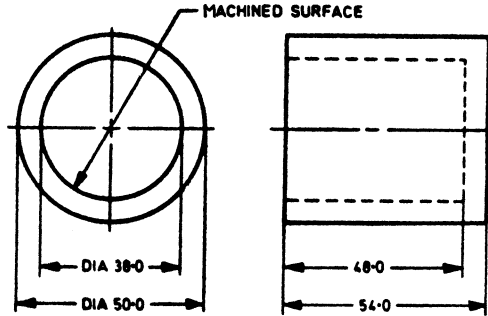
NOTE 1 — Dashed lines indicate unspecified contour or structure.

NOTE 2 — Tolerance is ± 2.0 mm unless otherwise noted.

All dimensions in millimetres.

FIG. 1 DUMMY HEAD

The acoustic isolation of the dummy head shall be no less than 60 dB in any test frequency band in the range of interest. Isolation shall be determined as the difference, at each test band between the output of the microphone uncovered and of the microphone covered with a thick-walled metal cup, grease sealed to the hard surface of the dummy head. A sample test cup is shown in Fig. 2.



NOTE — One metal cup fabricated to the dimensions shown has provided adequate isolation in practice.

All dimensions in millimetres.

FIG. 2 ACOUSTIC ISOLATION TEST CUP

B-1.1.2.2 Observed sound pressure level apparatus — An automatic graphic level recorder (pen speed of 10 mm/s and paper speed of 25 mm/s have proved satisfactory) synchronized with either a stepping-type or a continuously swept third-octave filter set is the recommended instrument for measuring the sound pressure level. A manually scanned filter may be used with a voltmeter readout (slow meter response is mandatory). A simultaneous visual/graphic analyzer or a standard sound pressure level meter with third-octave band analyzer may also be employed. The measuring system used shall be calibrated to measure band pressure level with reference to $20 \mu\text{Pa}$.

B-1.1.2.3 Headband force apparatus — The apparatus for the measurement of headband force is described in Fig. 3.

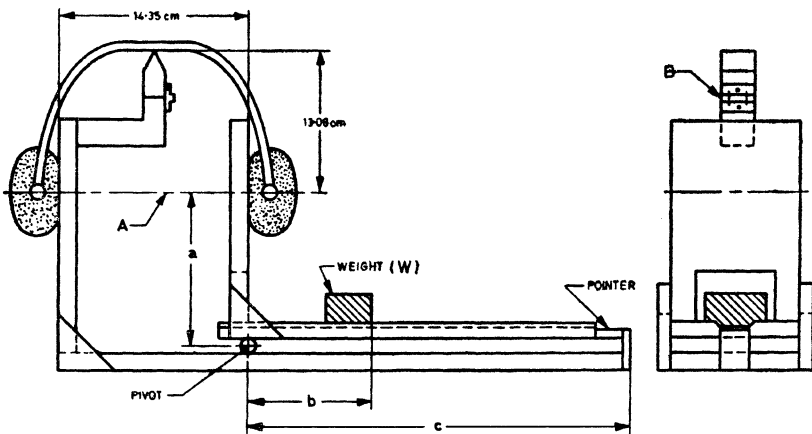
Construction — Almost any material can be used providing that the units are made sufficiently rigid. The only critical dimensions are the earcup separation distance (14.35 cm) and the headband extension distance (13.08 cm). For best results, dimension *a* should be 12.0 cm to 15.0 cm and dimension *c* should be 30.5 cm. A good free-working hinge with a small centre pin is satisfactory as the pivot point. Weight is recommended to be about 900 g.

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Calibration — With the pointer aligned, the distance between the two faces shall read 14.35 ± 0.2 cm. If the construction is such that the weight can be moved over the pivot point, then the zero force location is found by positioning the weight where it just balances. The force (F) at any location at a distance b that the weight has moved from the zero point is found by $F = bW/a$. A scale of grams can be marked.

Operation — The ear-muff to be measured is positioned so that the points of attachment of the headband to the earcups are located at the centerline marks (13.08 cm) and the headband contacts the vertical post. The post is moved away, and the weight is positioned to where the pointers are aligned. The force is read from the scale which converts weight location into grams. When the pointers are aligned, the distance of 14.35 cm is automatically satisfied.

Accuracy — The positioning of the earcup shall be done with care in order to ensure that the point of attachment of the cup to the headband is the distance a from the pivot point. Practically, this is the largest source of error. With care, the position will be in errorless than 0.3 cm for a maximum measurement error of $0.3 \text{ cm} \div 12 \text{ cm} = 2.6$ percent (2.1 percent for $a = 15$ cm). Actual measurements of ten different hearing protectors by three different persons have shown that 95 percent of the measurements will be within ± 5 g.



NOTE 1 — A: Centerline passes through pivot point of earcup attachment to headband.
NOTE 2 — B: After correct headband distance is obtained, move out of way for force measurement.

FIG. 3 FORCE MEASUREMENT SYSTEM

B-1.2 Test Procedures

B-1.2.1 Attenuation Measurement

B-1.2.1.1 Ear-muff placement — Ear-muff shall be positioned in the following manner. The adjustable headband shall be extended to its largest size. The hearing protector shall be spread and placed on the dummy head with the circumaural seals centrally located on the appropriate surfaces. The headband shall be contracted so as to rest firmly upon the curved surface of the dummy head.

NOTE — Nape spring hearing protectors or those do not have rigid headband springs shall be positioned on the dummy head in accordance with manufacturer's instructions. The applicable conditions of **B-1.2.1.1** shall be met.

B-1.2.1.2 Measurement — The band pressure levels at the microphone shall be measured for the acoustic test field without earmuffs. The hearing protector shall be placed over the microphone in accordance with **B-1.2.1.1** and the band pressure levels measured again. Readings are taken at the preferred centre frequency when continuously swept filter sets are used.

- a) The measurements shall be taken for each earcup of the hearing protector in position covering the test microphone.
- b) When the measured difference in band pressure levels between the right and left earcups is less than 5 dB, the arithmetic average of the two values shall be reported. When the measured difference between earcups is 5 dB or greater, the attenuation of each earcup shall be reported.

B-1.2.1.3 Hearing protector attenuation — The algebraic difference in band pressure level, in decibels, for each test frequency band with and without the hearing protector in place on the dummy head is considered to be the attenuation of the device.

B-1.3 Reporting the Data

B-1.3.1 The hearing protector attenuation data shall be presented in graphic form, with the data points connected by straight lines, on a paper whose frequency scale along the abscissa is in equal intervals of one-third octave-band centre frequencies and whose attenuation scale along the ordinate is linear in decibels. The length for a decade of third-octaves shall be equal to the length for 25 dB. The ordinate shall

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be labelled in 14 equal intervals of 5 dB ranging from 60 dB at the abscissa to -10 dB. Subdivision of the ordinate is acceptable.

B-1.3.2 The graph shall be clearly labelled to indicate a physical measurement method. The date, model number, headband force, individual conducting the test, and any other appropriate data shall be included on the graph.

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